

Adaptation of GEANT4 for Single Event Simulations

**R. A. Weller, A. L. Sternberg, A. S. Kobayashi,
M. H. Mendenhall, L. W. Massengill,
R. D. Schrimpf and D. M. Fleetwood**

**Department of Electrical Engineering &
Computer Science**

Vanderbilt University

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robert.a.weller@vanderbilt.edu

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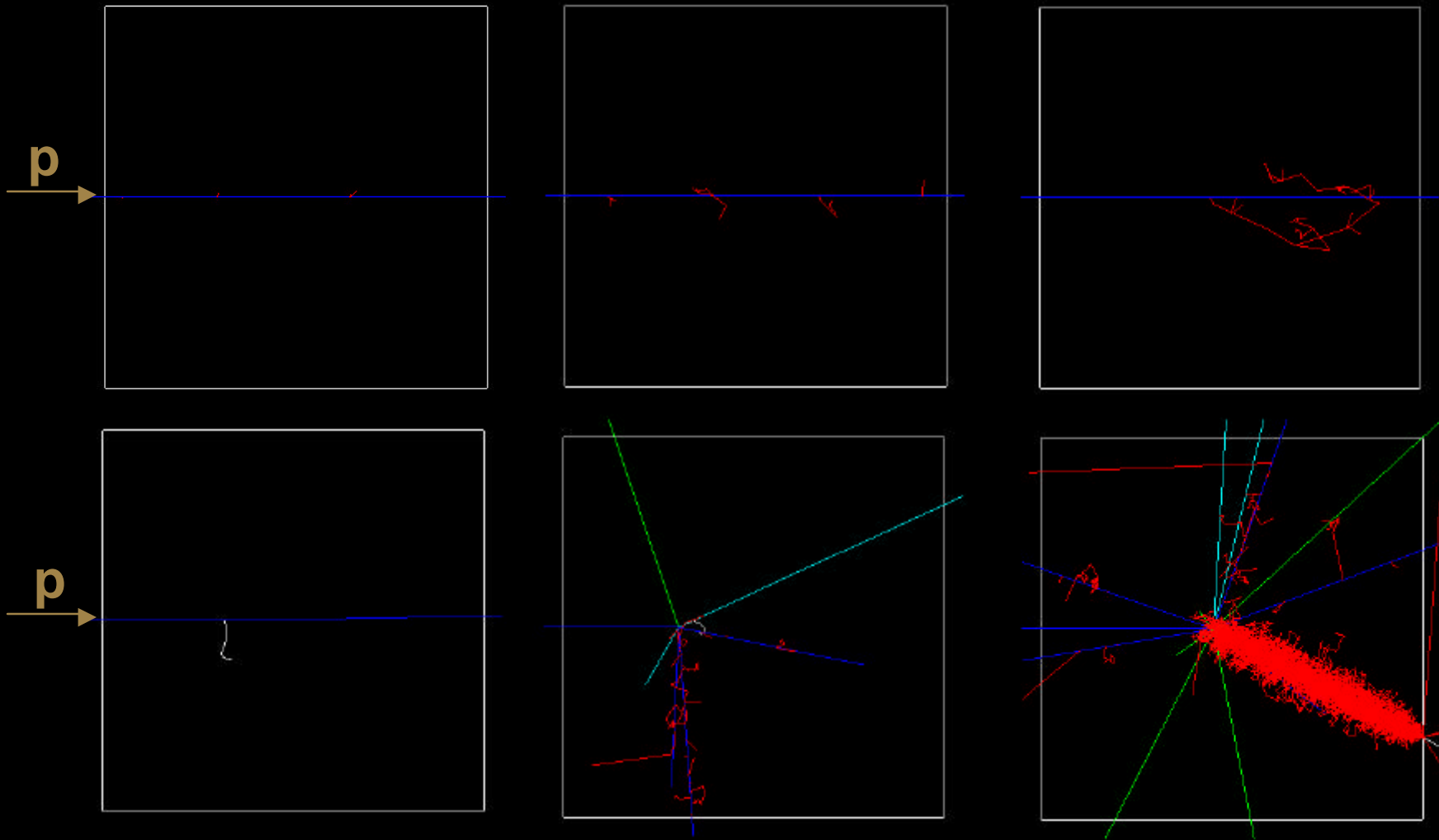
Overview

- What is GEANT4?
- Why use it?
- What is our strategy?
- How is the strategy implemented?
- What is the result?
- Summary (Current)
- What is next?



GEANT4? A Simulation Toolkit...

S. Agostinelli et al. "Geant4 - a simulation toolkit," Nucl. Instr. Meth. A506 (2003) 250.



100 MeV protons ? 5 μm Si

robert.a.weller@vanderbilt.edu

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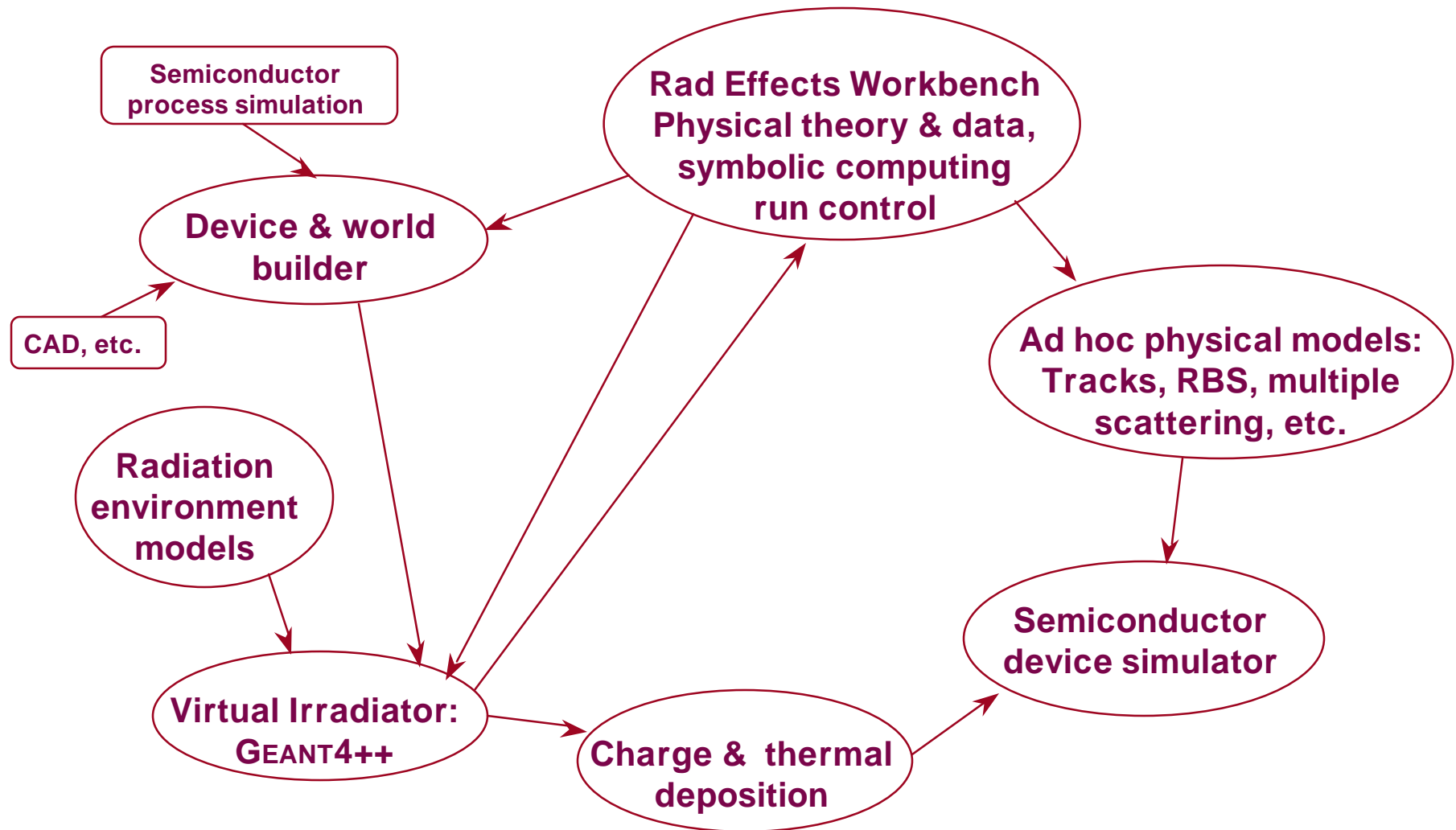
Why use GEANT4 for radiation effects in electronics?

For an excited system, the average response, is not, in general, the response to the average excitation.

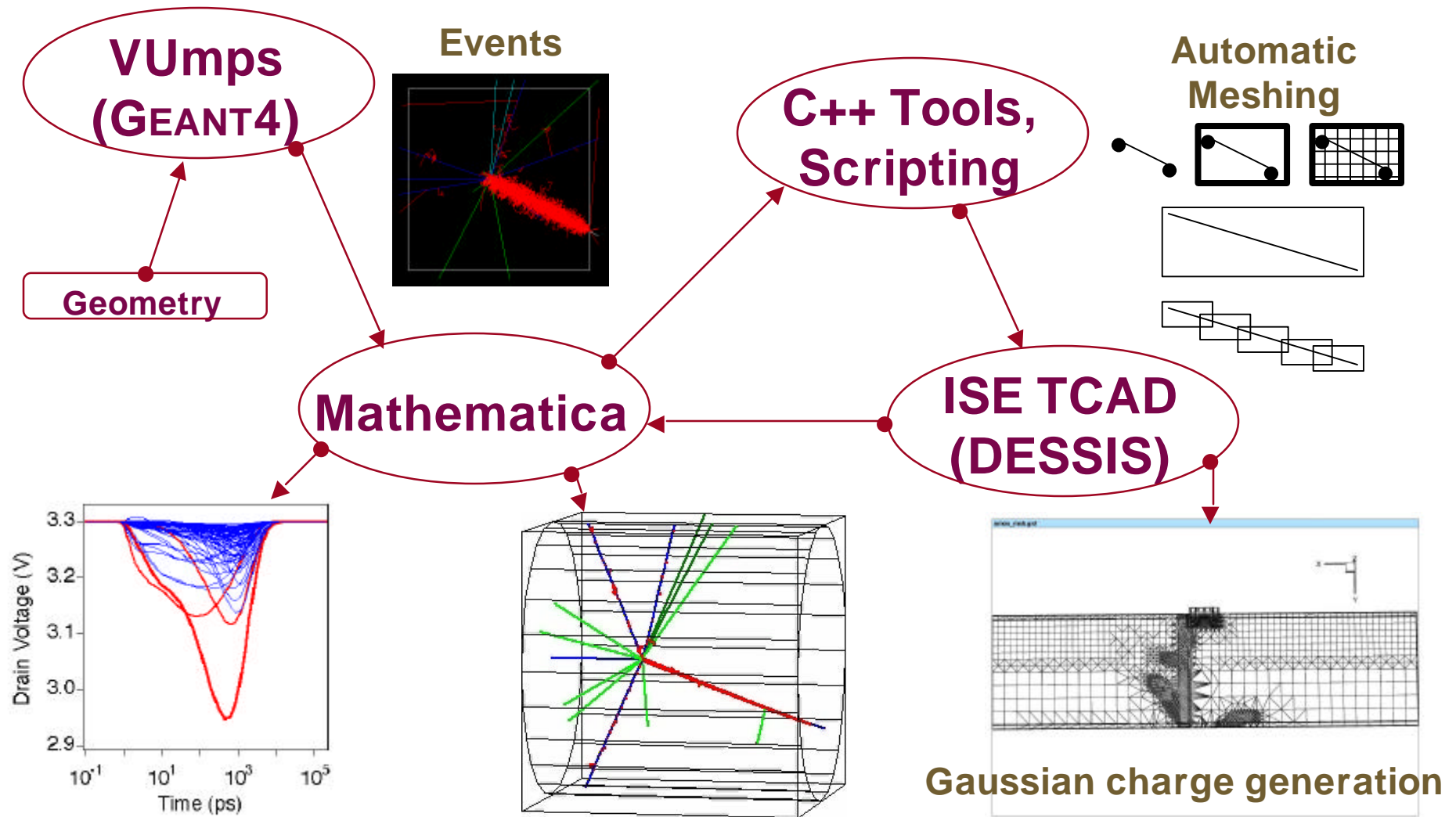
Translation: For very small devices, all events are single events.



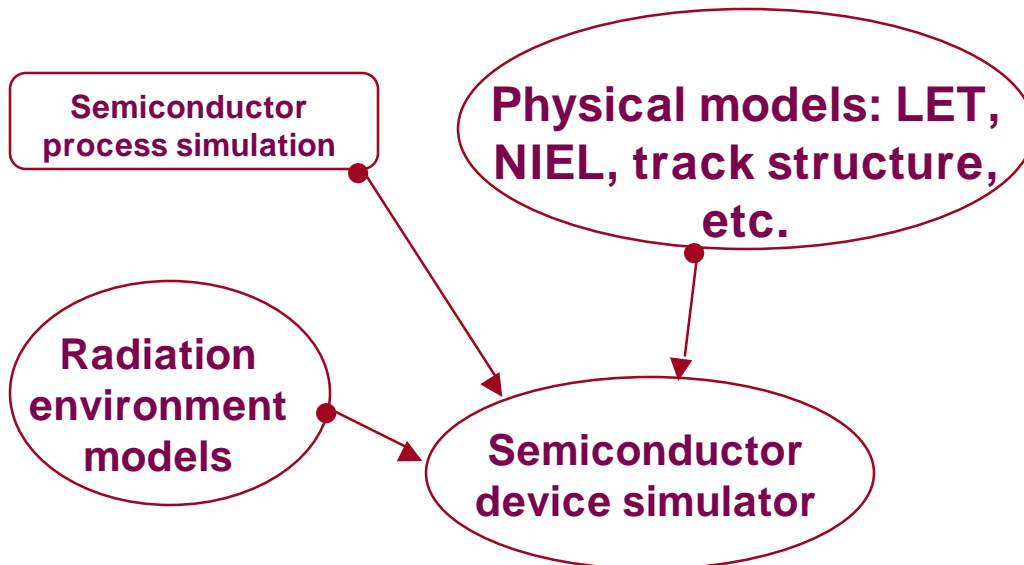
Strategy? The Virtual Rad Lab



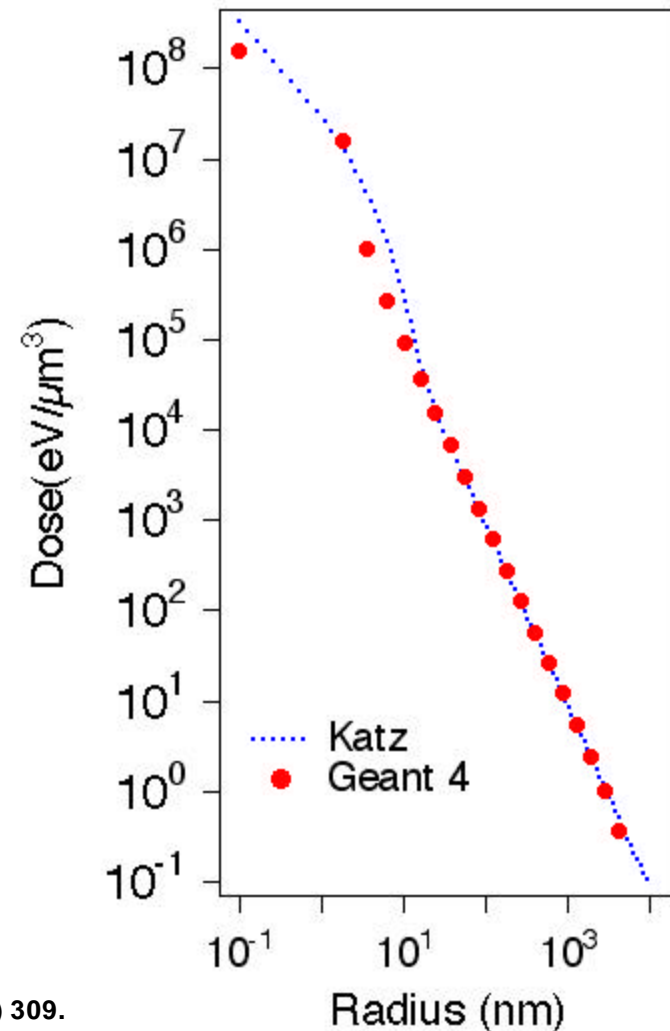
Implementation? How it works...



Result: Radial Track Structure



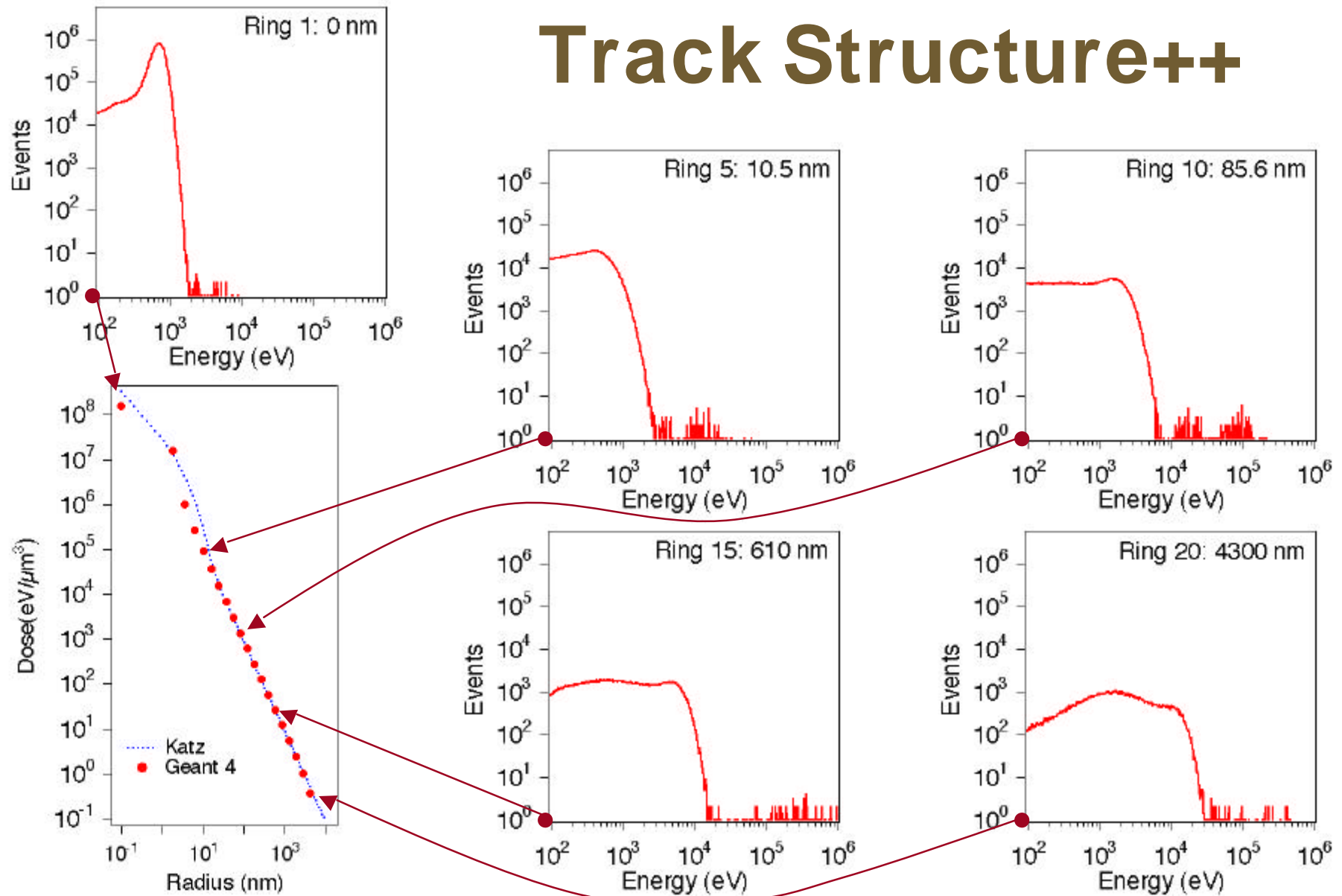
100 MeV protons in Si



M. P. R. Waligórski, R. N. Hamm & R. Katz, Nucl. Tracks Radiat. Meas. 11 (1986) 309.

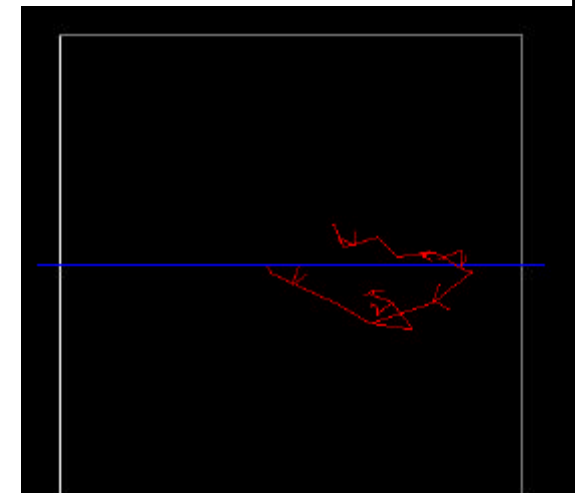
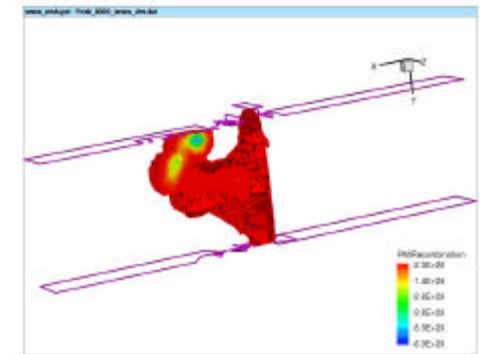
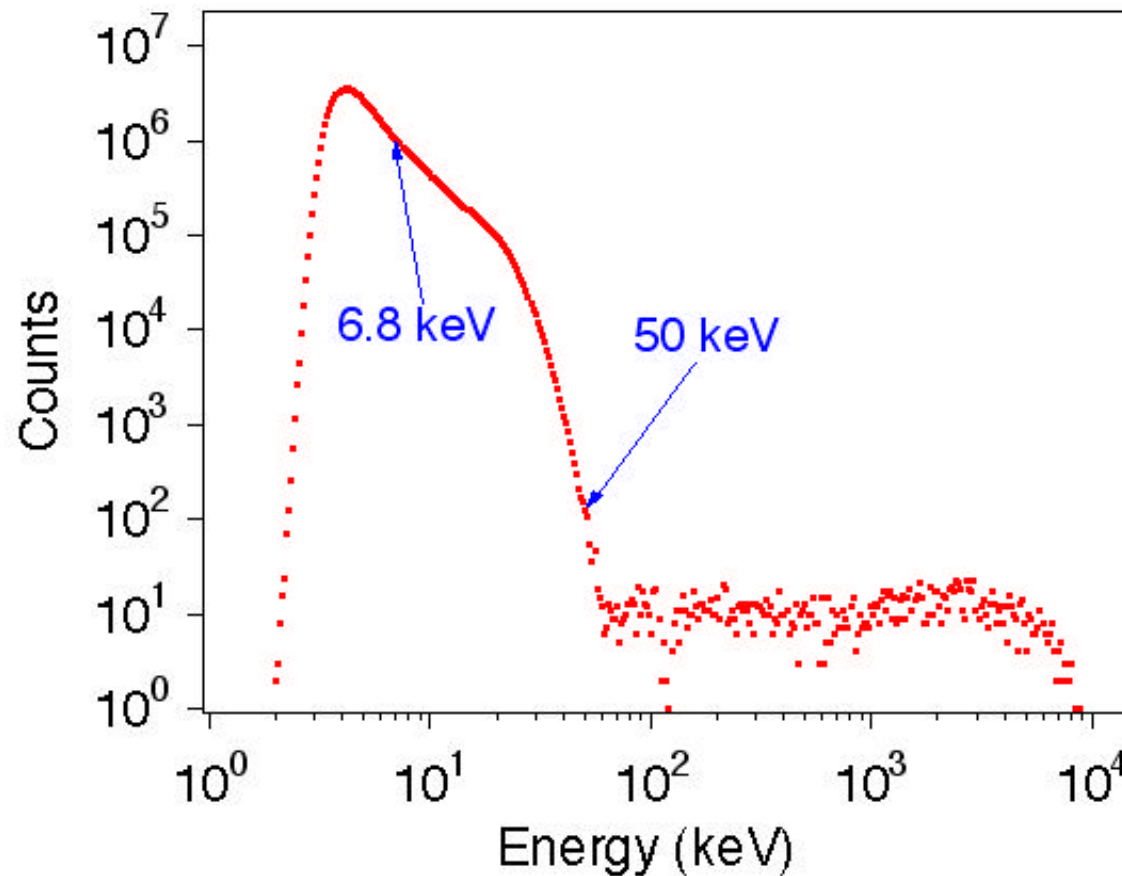


Track Structure++



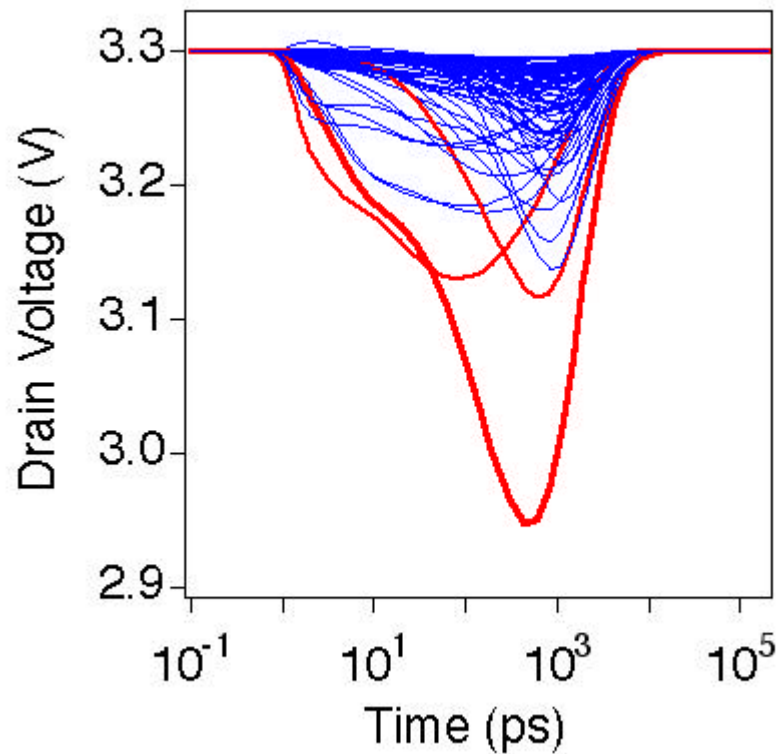
Result: MOS transistor response to energetic γ -ray events

Supply = 3.3 V $R_L = 200\text{ k}\Omega$ Biased off

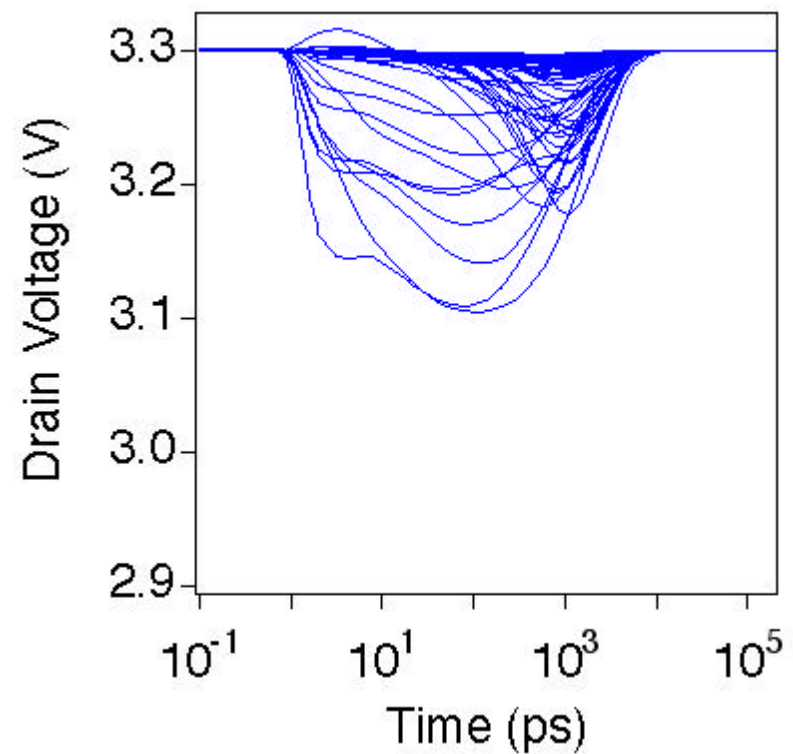


Drain Voltage Pulses

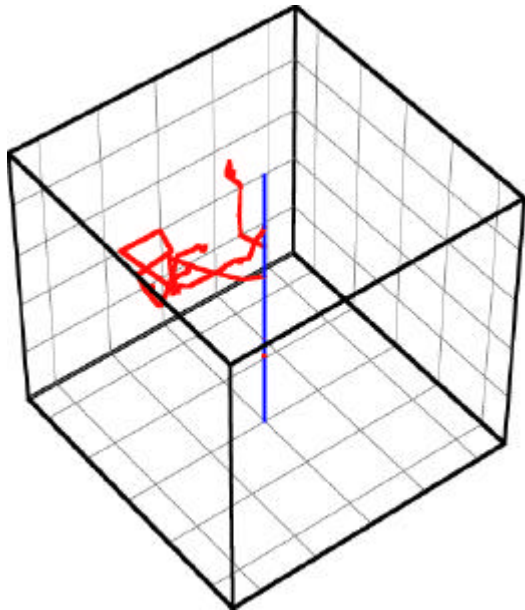
100 MeV protons



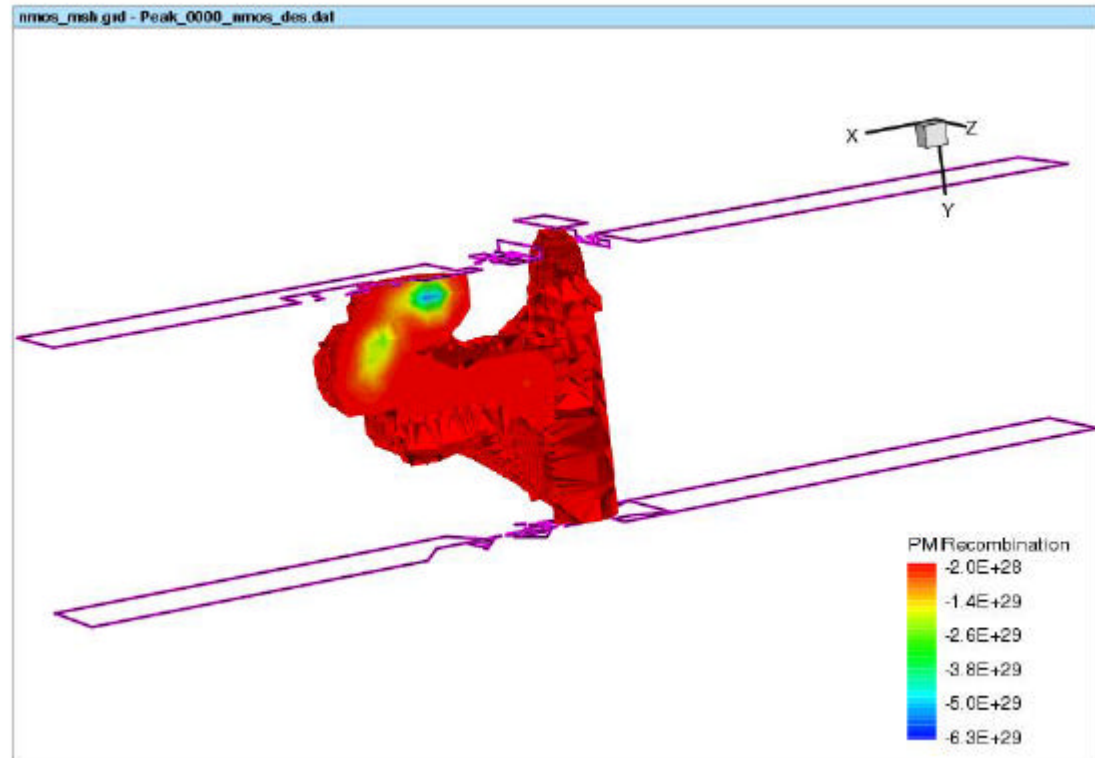
200 MeV protons



The largest event : $\sim 10\% V_{DS}$



Particle Trajectories
Incident proton: blue
Electrons: red

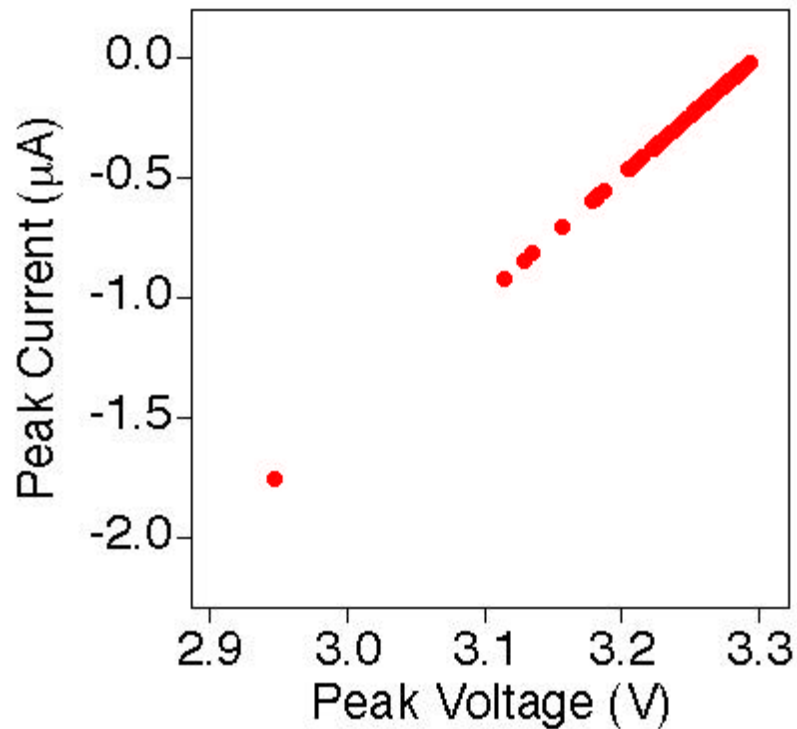


Energy in the transistor: 44.7 keV

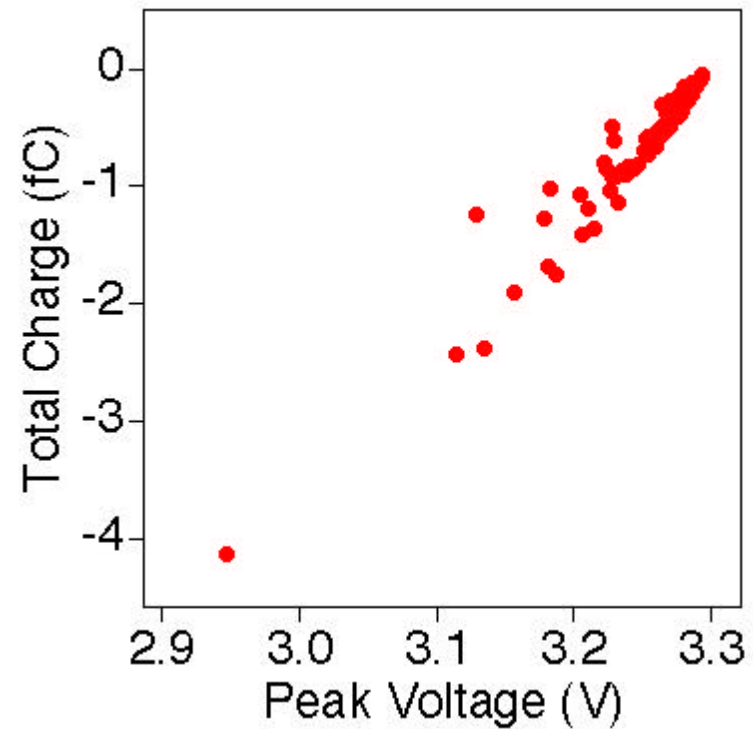


Consistency Checks

Derivative = $R_L = 200 \text{ k}$?

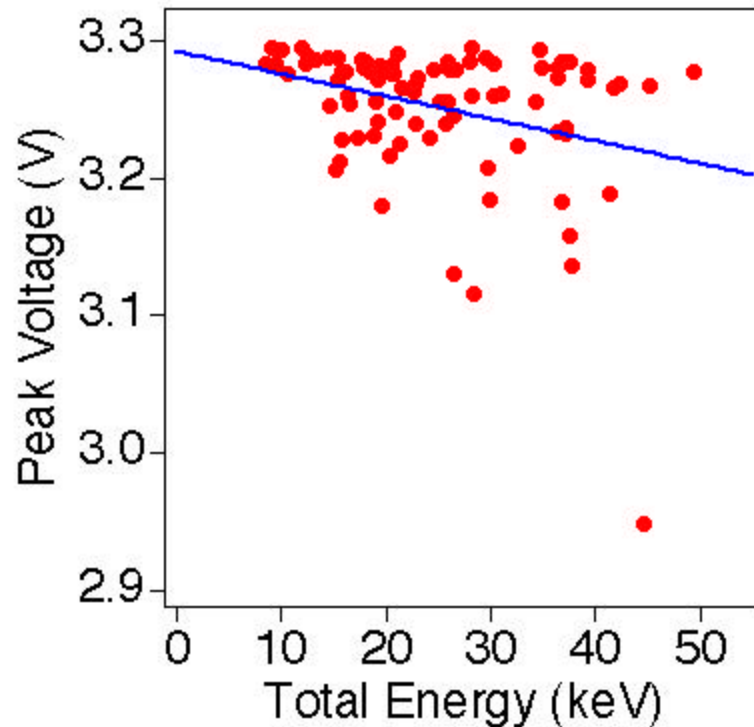


Pulse shape variability!

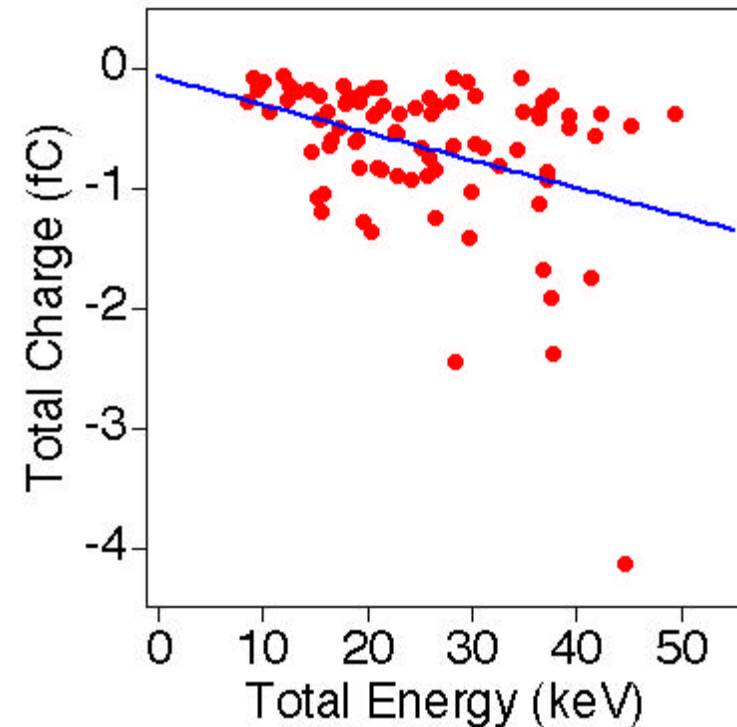


Pulse amplitude vs. event energy

Minimum V_{DS} & fit



Integrated I_D & fit



Note the dispersion!



Summary

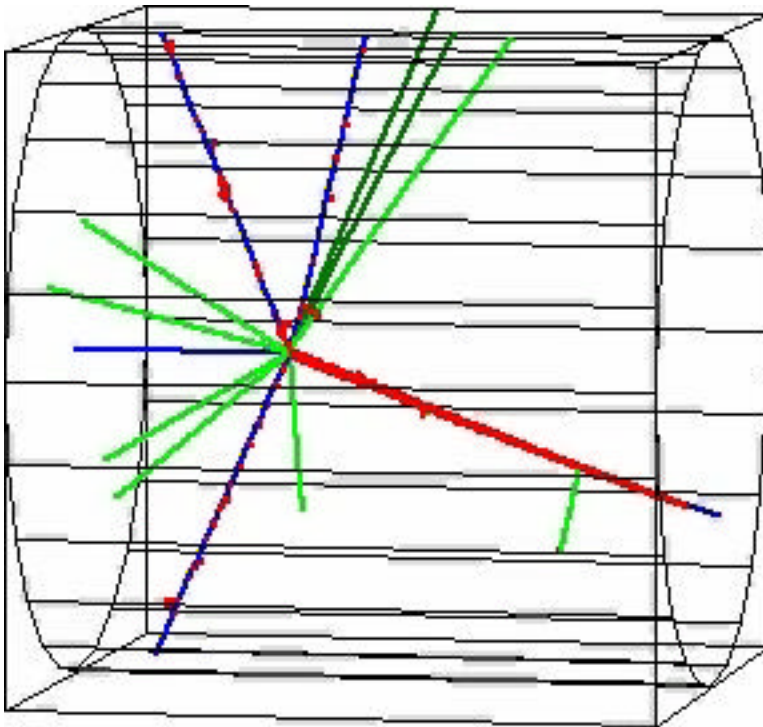
- The basic framework for ensemble simulation of single events is in place and tested.
- The methodology has been demonstrated by application to low-probability, high-energy, discrete γ -ray events.
- Development of both the overall SEE strategy and the GEANT4 libraries is ongoing.



What's next?

300 MeV p ? 5 μm Si

? E ? 18 MeV



Code: Red = e^- ; Blue = + ion; Green = n, ?, etc.

- Realistic geometry
- Proton nuclear reactions
- Screened Coulomb scattering
- Heavy-ion nuclear reactions
- Validation
- Statistical studies
- Practical circuits
- Cross section

